

# **Atmospheric Plasma Depainting**

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<b>Report Documentation Page</b>			<i>Form Approved OMB No. 0704-0188</i>		
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1. REPORT DATE <b>19 NOV 2014</b>	2. REPORT TYPE	3. DATES COVERED <b>00-00-2014 to 00-00-2014</b>			
4. TITLE AND SUBTITLE <b>Atmospheric Plasma Depainting</b>		5a. CONTRACT NUMBER			
		5b. GRANT NUMBER			
		5c. PROGRAM ELEMENT NUMBER			
6. AUTHOR(S)		5d. PROJECT NUMBER			
		5e. TASK NUMBER			
		5f. WORK UNIT NUMBER			
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) <b>Atmospheric Plasma Solutions, Inc,11301 Penny Road ??? Suite D,Cary,NC,27518</b>		8. PERFORMING ORGANIZATION REPORT NUMBER			
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)		10. SPONSOR/MONITOR'S ACRONYM(S)			
		11. SPONSOR/MONITOR'S REPORT NUMBER(S)			
12. DISTRIBUTION/AVAILABILITY STATEMENT <b>Approved for public release; distribution unlimited</b>					
13. SUPPLEMENTARY NOTES <b>ASETSDefense 2014: Sustainable Surface Engineering for Aerospace and Defense, 18-20 Nov 2014, Fort Myer, VA.</b>					
14. ABSTRACT					
15. SUBJECT TERMS					
16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT <b>Same as Report (SAR)</b>	18. NUMBER OF PAGES <b>33</b>	19a. NAME OF RESPONSIBLE PERSON
a. REPORT <b>unclassified</b>	b. ABSTRACT <b>unclassified</b>	c. THIS PAGE <b>unclassified</b>			

# Outline

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- Problem Statement
- Define Plasma
- Define Atmospheric Plasma
- Describe Atmospheric Plasma Coating Removal (APCR)
- Benefits of APCR
- Introduce the PlasmaFlux™ APCR system
- Aerospace Depainting Efforts
- Navy Ship Depainting Efforts

# Problem Statement

- Annual cost of corrosion for DoD  
~ \$22 Billion
- Virtually every weapon system  
across all segments of DoD  
require periodic maintenance of  
coating systems



High Pressure Water Jet



Plastic Media Blasting



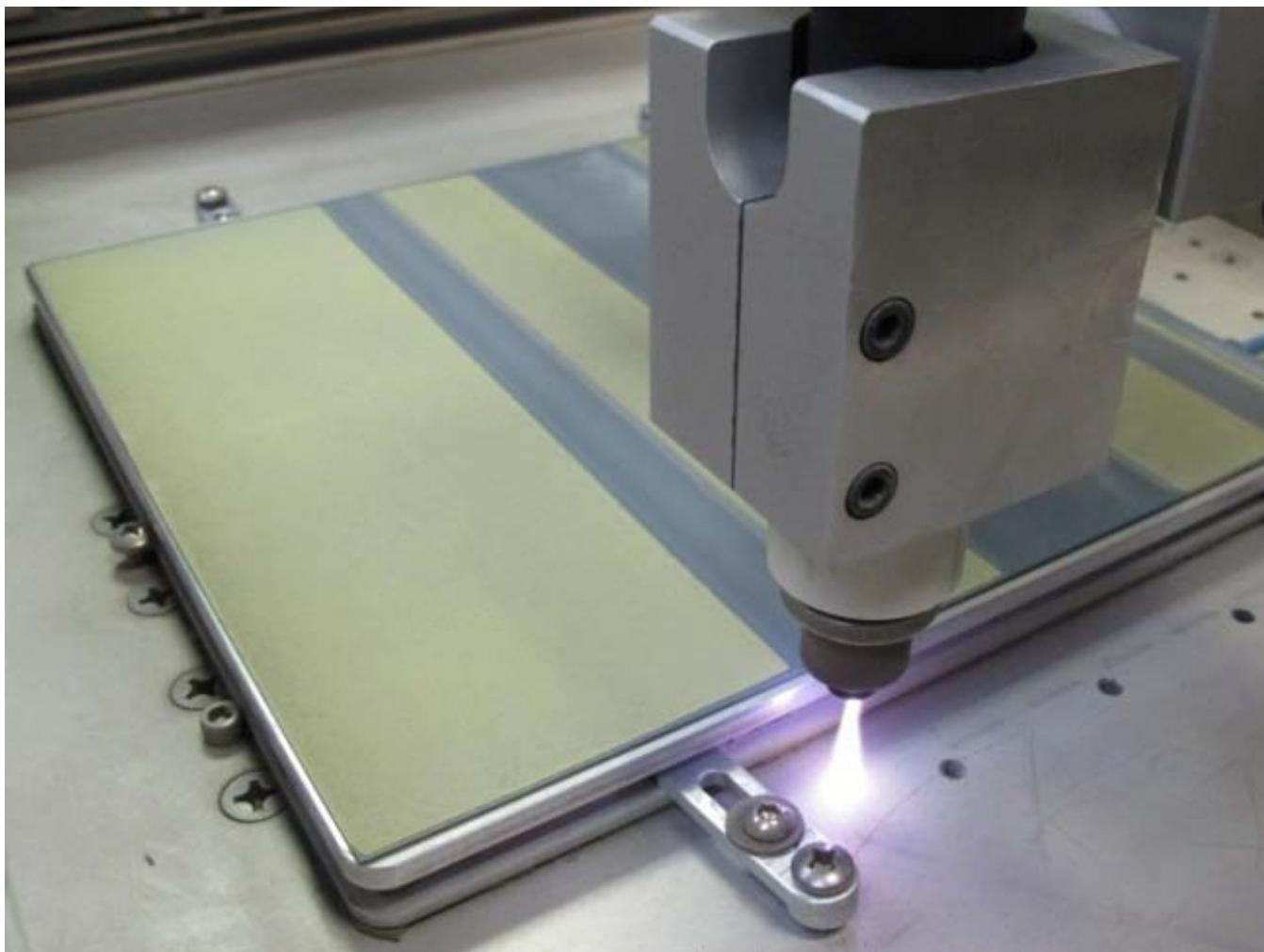
Grit blasting

# Problem Statement

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- Conventional paint and coating removal techniques are based on a variety of mechanical or wet chemical techniques.
  - Media based (sand/grit, dry ice, and plastic media blasting)
  - High pressure water
  - Liquid Solvent Chemical stripping
- Disadvantages
  - Labor intensive
  - High materials cost (procurement, storage, transport, disposal)
  - High environmental cost (solid / liquid waste disposal)
  - Potentially damaging to some substrate materials (composites)

# Solution: Atmospheric Plasma Coating Removal



# What is Plasma?

# Plasma: Fourth State of Matter

Increasing Energy



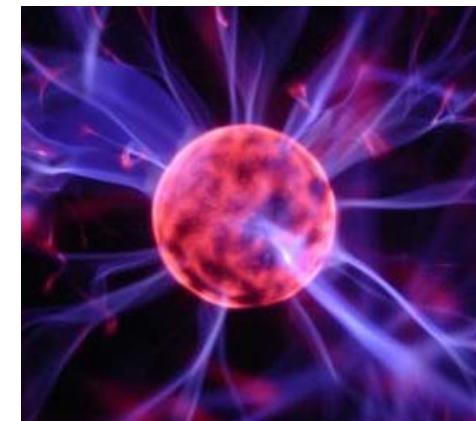
Solid



Liquid



Gas



Plasma



State of Matter

# What is Atmospheric Plasma?

# What is Atmospheric Plasma?

- **Plasma occurring at Atmospheric Pressure**
- **Plasma with Atmospheric Composition  
(Compressed air is only gas required)**



# Atmospheric Plasma Coating Removal (APCR)



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Atmospheric  
Plasma

Paint / Sealant

Carbon  
Dioxide

Water  
Vapor

- APCR requires no media
- Atmospheric plasma produces highly reactive gas
  - Cold plasma ⇒ high chemical energy, low thermal energy
  - Vaporizes organic portion of coatings to CO<sub>2</sub> and H<sub>2</sub>O
  - No damage to temperature sensitive substrates



# Features and Benefits of APCR Technology

Feature	Benefit
No Media Required	Cost - Reduced procurement, storage, and disposal costs Safety - Reduced exposure to hazardous materials Environmental – Reduced environmental impact
Atmospheric Pressure Operation	Non-damaging removal, preserves surface profile Selective layer-by-layer removal Consumables: Compressed Air and Electricity Safety – No special safety equipment or procedures Cost – Eliminates need for “hot work” zones, faster maintenance cycle
Compact size, low weight	Controlled manually or by robotics Reaches areas that are inaccessible to other technologies

# PlasmaFlux™ APCR Technology

## Power Supply



## Plasma Source



- The power supply produces a high frequency electric field to generate cold plasma
- Depot compatibility: Requires only compressed air and electrical power



# Aerospace Depainting Efforts

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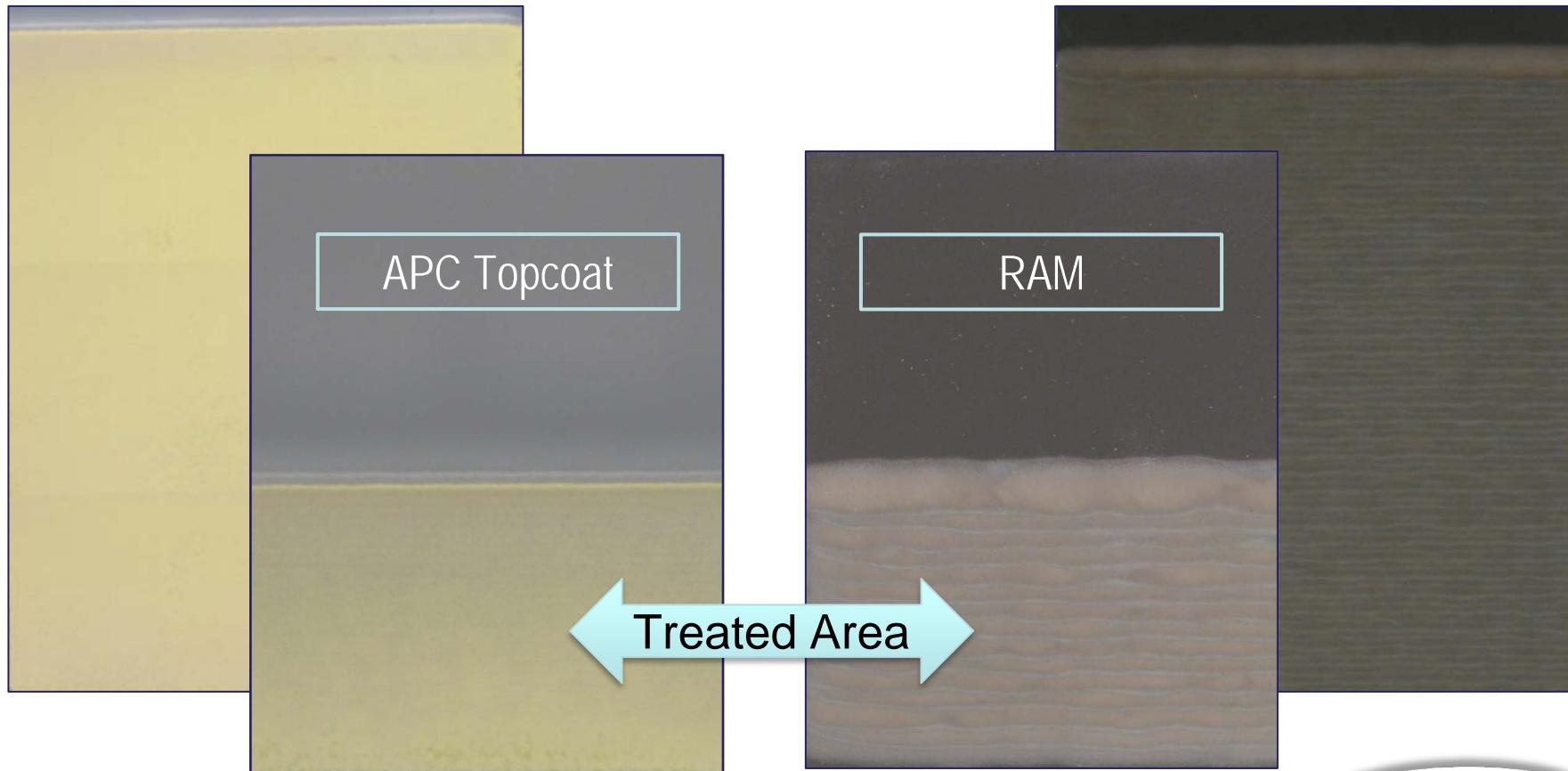
- APC (Advanced Performance Coating), RAM (Radar Absorbing Material), and Sealant removal
- Aluminum, Titanium, Composite substrates
- Accessing confined spaces where other technologies struggle



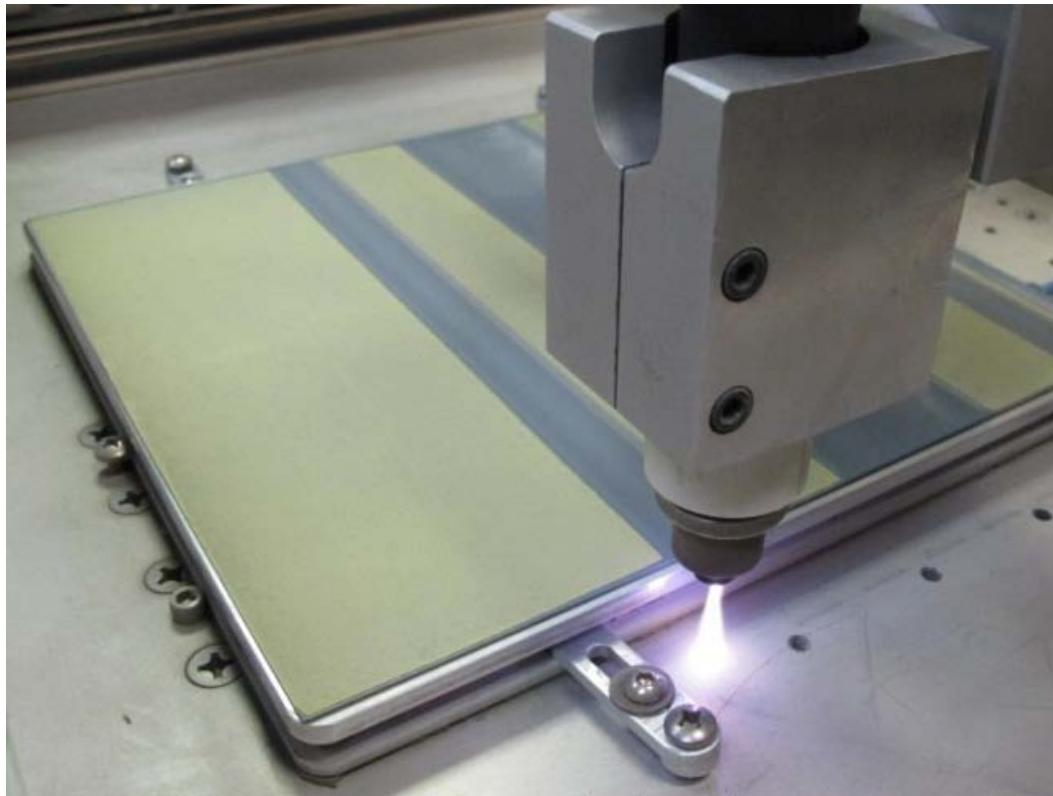
# Aerospace Depainting Efforts

APC on Aluminum  
Removal to Primer

RAM on Carbon Fiber  
Partial Topcoat Removal



# Aerospace Depainting Efforts



- Selective layer-by-layer removal has been demonstrated on contoured substrates using 3-axis automated systems

# Hand Held Removal of Polysulfide Sealant

**AC-240-B2 Sealant  
(2-5 mm thick)  
applied to lap joint with  
protruding rivets**



**~15 second handheld  
removal around rivet leaving  
bare metal and powdery  
residue**

# Primer Removal, Sealant Removal

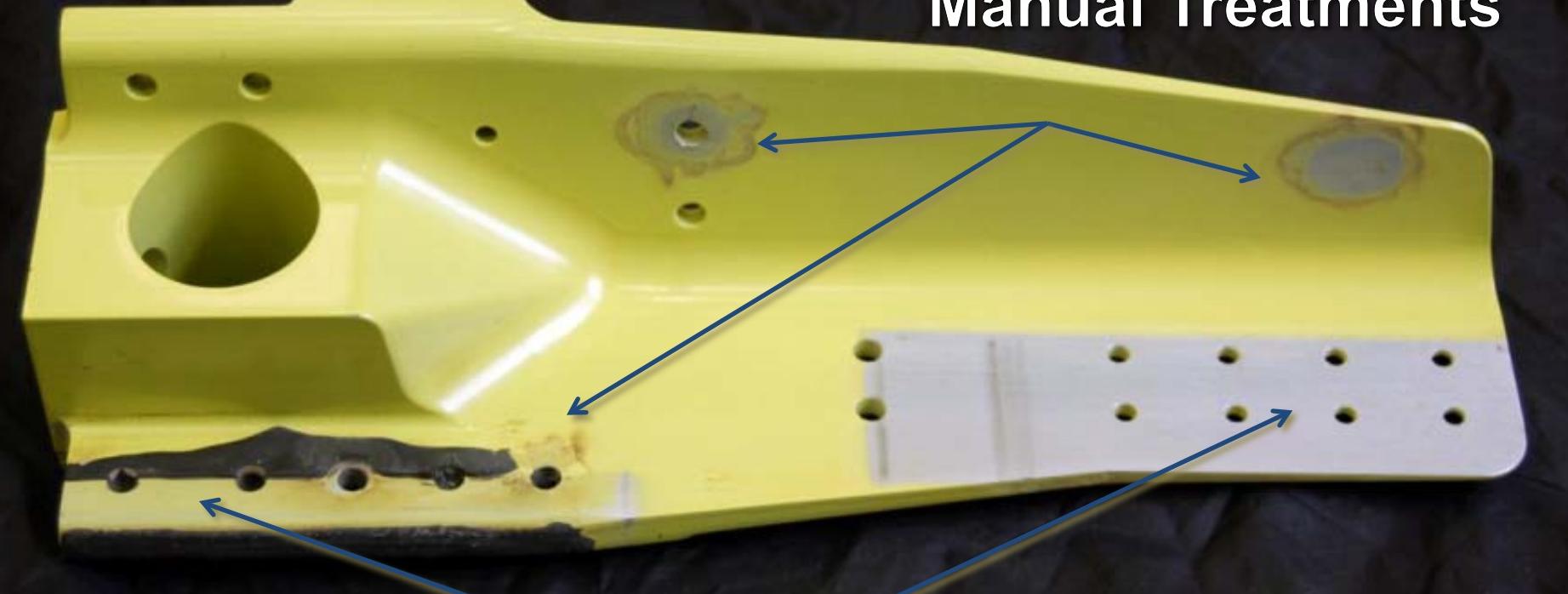
## C-130 Aluminum Wing Corner Fitting



# Primer Removal, Sealant Removal

## C-130 Aluminum Wing Corner Fitting

Manual Treatments



Automated Treatments

# Aerospace Coating Removal Transition Programs

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- AFRL (WPAFB)
  - Evaluation of high power atmospheric plasma process for aircraft coating removal
  - Evaluation of handheld APCR for Sealant removal
- NAVAIR (Cherry Point)
  - Evaluate AP for weld surface prep on Nickel Superalloys
- Ongoing projects with prime contractors
  - Evaluating APCR for surface treatment of aircraft fasteners and sealant removal
  - Evaluating removal of specialty LO coatings on composite substrates

# Naval Depainting Development Programs

- Navy Phase I & II SBIR (N00014-10-C-0266)
  - Projects focused on engineering development challenges
    - Modular 20kW, Stackable Power supplies
    - Improved single and multi-pen designs
    - Ruggedization for Dry-dock environment
    - Operation using Dry-dock 480V 3-phase power

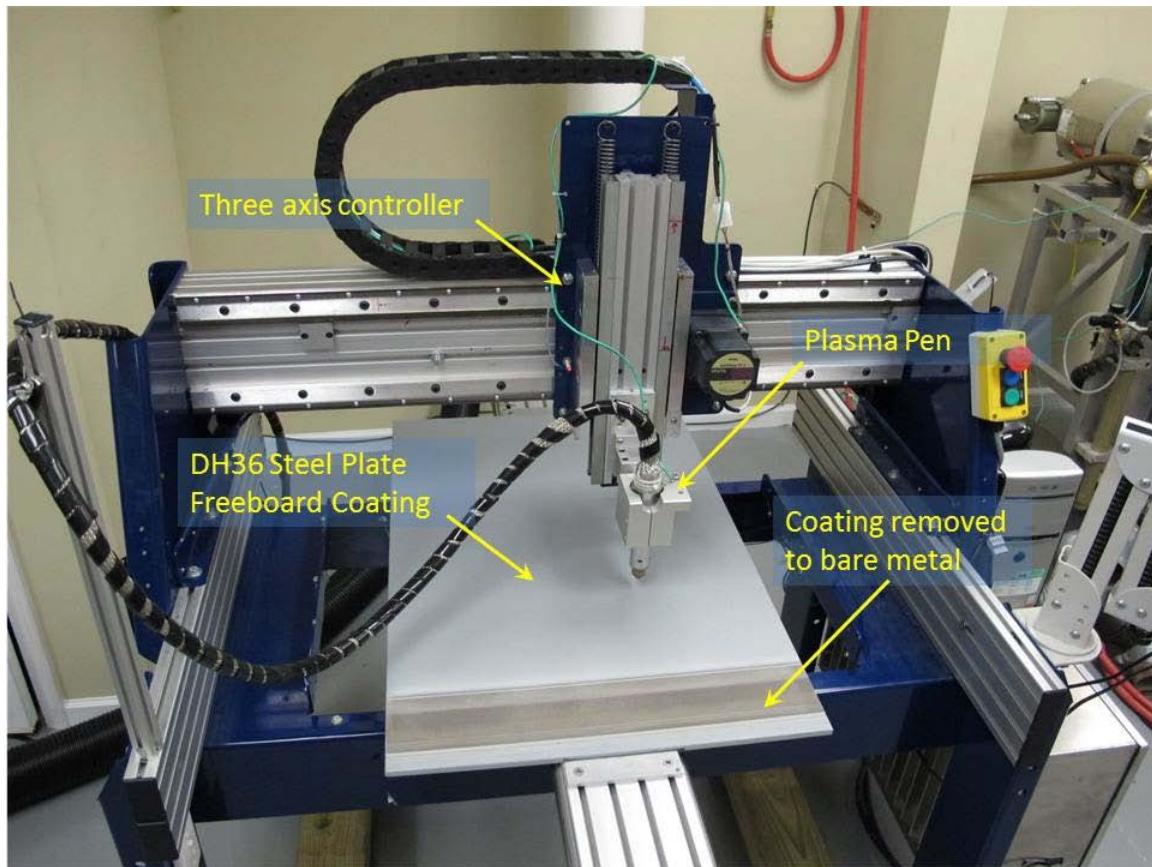
# Naval Depainting Development Programs

- SERDP WP-1762 (NCSU Lead, APS Co-performer)
  - Recoating performance of APCR depainted surfaces
  - Multi-pen removal process development using SBIR designed plasma system
  - Removal rate enhancement on Naval ship coatings
  - Plasma plume-surface interaction
  - Environment, Safety and Occupational Health characterization of the plasma depaint process



# Naval Coatings Removal

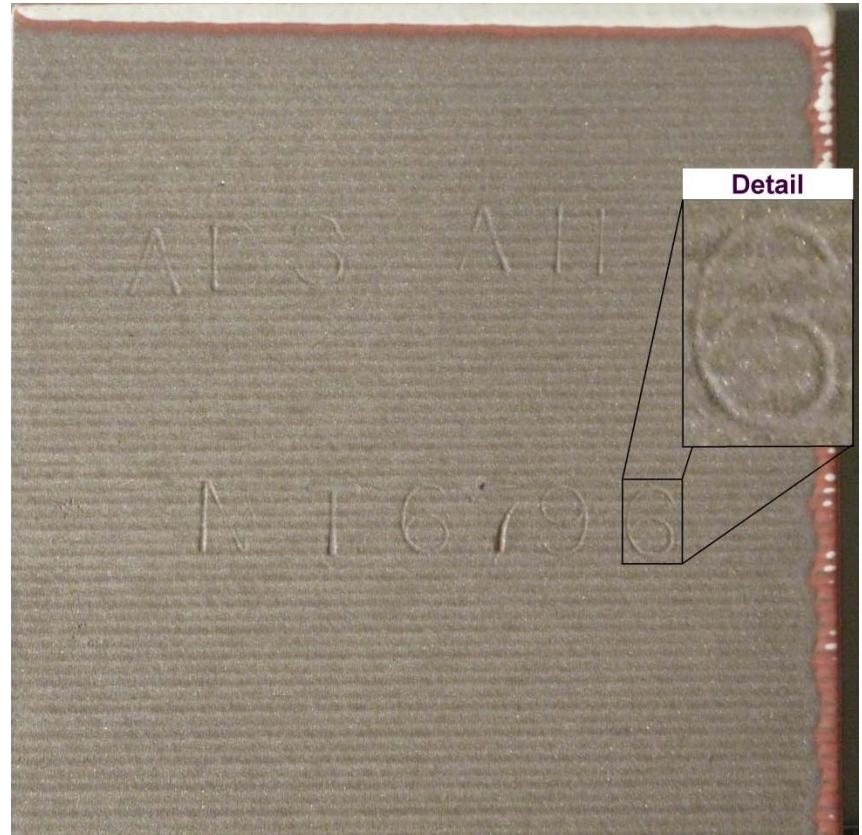
- Plasma pen integrates with COTS automated system for coating removal tests
- Sample coupons
  - 24" x 36" 3/8" DH36 steel
  - ( $\pm$  2.5 mil roughness)
- Coating stacks
  - Freeboard
  - Anti-Fouling
  - 20 mils thick (nominal)



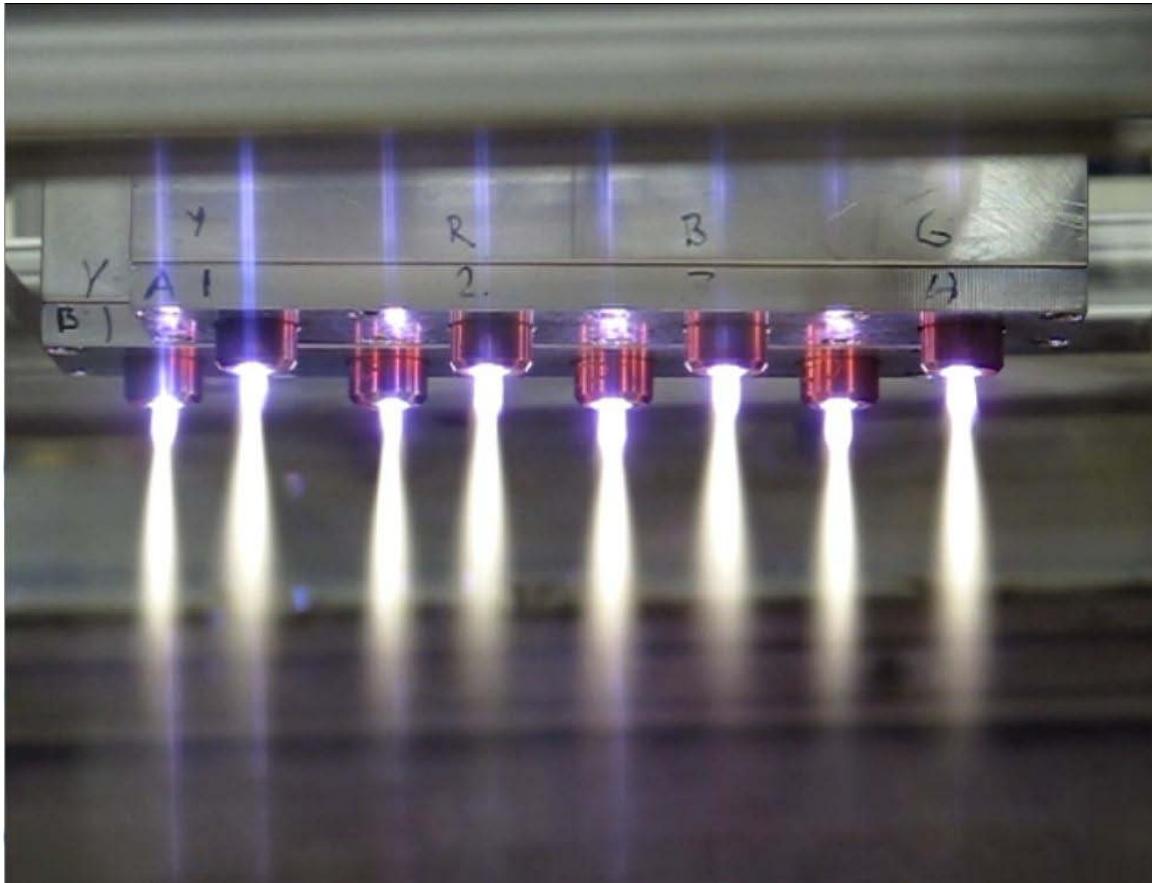
Three axis automated system

# Anti-Fouling Coating Removal

- APCR produces surface with “near white metal blast cleanliness”
- Underlying surface profile is unchanged
- Uniform removal demonstrated for freeboard and anti-fouling coatings
- Demonstrated excellent adhesion of re-applied coating with no secondary wiping or cleaning required to recoat



# APCR Multi-Pen Array



Eight Pen Array

# SERDP Program Findings

- Comparable efficacy of APCR to conventional Naval coating removal techniques
- Test panels were depainted by grit blasting and APCR to “near white metal” conditions and then repainted
- No significant performance difference of reapplied coatings was observed between APCR and grit blast surface preparation
  - No discernible difference in surface grain size, structure, or composition.
  - Pull-off adhesion tests of re-applied coating are comparable
  - No significant coating performance difference in salt fog and cathodic disbondment testing

# Solid Mass Reduction Study

Determine what % of coating is converted to vapor

- Closed system employed during coating removal to capture solid waste
- Results indicate that up to 60% of coating mass was converted to gaseous byproducts
- EDS analysis of solid residue showed primarily inorganic content
- Freeboard Silicone Alkyd, PRF-24635 46% reduction
- Antifouling, 60% reduction



# Technology Transition

- **Scale up plasma coating removal technology to increase production rates**
  - Increased power levels (power source and plasma pen)
  - Multiple Plasma Pens
  - Wide Area Plasma Source
- **Ruggedize power supply and pen for testing under depot conditions**
  - Outdoor marine environment: Category III, Pollution Degree 4
  - Compliance standards taken into consideration in design

# Technology Transition

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- **Seeking Strategic Partnerships to further develop APCR technology for specific applications, demonstration and evaluation**

# Acknowledgements:

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- Jeff Kingsley, WPAFB
- Natasha Voevodin, WPAFB
- Steve McElvany, ONR
- Bill Hertel, NSWC Carderock
- Darren Melhuish, NSWC Carderock
- Jerry Cuomo, NCSU
- Steve Hudak, NCSU
- Robert Kestler, NAVAIR- Cherry Point
- Bruce Sartwell, SERDP/ESTCP
- Robin Nissan, SERDP/ESTCP

# **Support Provided, in part, by the following U.S. Gov. contracts:**

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- FA8650-08-M-5606
- N00014-09-M-0161
- FA8650-09-C-5607
- FA8650-09-D-5600/0005
- N00014-10-C-0322
- FA8650-05-D-5610/0011
- SERDP WP1762

# Thank You, Questions?

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# Complete Integration of AP coating removal with High Performance Robotics

